Test and Training ENabling Architecture (TENA)

TENA BASELINE PROJECT REPORT
Volume VIII
Transition Plan

Under Secretary of Defense (Acquisition & Technology)

Director, Test, Systems Engineering and Evaluation

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Abstract

The Test and Training ENabling Architecture (TENA) Project Transition Plan is designed to support transition of the architecture to the services and DoD agencies. It identifies transition responsibilities, presents a transition process, discusses the stakeholders, identifies some issues and concerns, and provides recommendations about management and oversight. The fundamental acceptance of the Product-Line Approach (PLA) is key to the successful implementation of the TENA architecture. The range community can accomplish significant movement towards major objectives of reduction, restructuring, and revitalization by implementation of the architecture alone, but these gains will be short-lived without a well-planned strategy for life-cycle support. The PLA is the fundamental key to enable necessary increases in range productivity and to maintain or improve that productivity over time.

Range architectures to date have been range-centric, meaning that the focus has been on the environment, facilities, sensors, processors, and analysis systems, rather than on the customer and his individual exercise requirements. We have always tried to make the test or exercise fit the range, rather than the other way around. Now, with advances in networking and computing technology and a new architecture, we can meet the requirements of customers better and test smarter using a concept called the "logical range." TENA introduces a new customer-focused architecture.

A transition process based upon the Product-Line Approach is presented here. Architecture life-cycle supportability issues are addressed, as are concerns with transition management and oversight. The Transition Plan will be updated to reflect new concepts learned through discussions with the sponsor, users, and range communities.

This process begins with prototypes of TENA in a scenario-based analytical phase and a controlled pilot concept exploration in FY98. Successful testing of critical features of the architecture will reduce implementation risk. During FY99 an operational testing phase is expected to support delivery of the system architecture ready for installation at one or more DoD selected ranges or facilities for parallel operational testing. This testing will culminate in FY00 with the establishment of a TENA-compliant operational system.

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Purpose

Two new concepts are introduced in the TENA Baseline Project Report, the Product-Line Approach (PLA) and the Logical Range. These concepts are fundamental to successful implementation of the TENA Architecture. This Transition Plan is designed to support transition of these concepts, as well as the TENA architecture.

Readership

The Transition Plan is intended for range management and operation directors and others in a range-management oversight or DoD and Service decision-making role. Some of these people are identified as TENA stakeholders who have a major interest in the reduction, restructuring, and revitalization of test and training.

Relationship to Other Volumes

Other technical information is found in different volumes of the TENA Baseline Project Report. Of most importance to this transition plan are the Product-Line Approach (Volume II), the Technical Reference Architecture (Volume IV), the Logical Range Business Process Model (LRBPM) (Volume V), and the Integrated Validation and Verification Plan (Volume VII). The PLA is fundamental and essential to engendering the cost savings required of DoD ranges in the future, but also to breaking the paradigms of the present. The LRBPM presents a methodology for conducting test or training exercises on a TENA compliant range. The Integrated Validation and Verification (IV&V) process is a key part of successful transition. A Glossary of Terms and Definitions is contained in Volume IX. Other supporting project information and documentation is presented in Volume X. Readers of this Transition Plan are encouraged to seek additional detailed information by consulting the appropriate volume.

PROJECT NEED

TENA is part of a coordinated response by the Central Test and Evaluation Investment Program (CTEIP) office to several current and emerging challenges in the test and training range and resource community. These challenges include:

- Reducing software development and maintenance cost,

- Utilizing common instrumentation at multiple facilities,

- Responding to the increased demand for multiple-site exercises and/or exercises which cross T&E/training or live/virtual/constructive boundaries,

- Responding to the increased demand for consistency of information between facilities and across phases of the acquisition process, and

- Capturing critical data to support informed customer and management decisions about resource needs, capabilities, and investments.

PROJECT PURPOSE

The purpose of the TENA project is to respond to these challenges through the establishment of an architecture that efficiently and effectively fosters the sharing, reuse, and interoperability between cooperating Department of Defense (DoD) test ranges and facilities, training ranges, laboratories, and other modeling and simulation activities. The expected synergism will permit efficient and effective testing of new and enhanced weapons systems and will vastly improve the scope and fidelity of worldwide joint/combined training.

PROJECT HISTORY

The Test and Training ENabling Architecture (TENA) project concept was formulated in FY95 by a multi-Service working group. This concept was endorsed by the Test and Evaluation Reliance Investment Board (TERIB), the Board of Operating Directors (BoOD), and the Test and Evaluation Resource Council (TERC).

The Navy is the CTEIP Resource Manager for this project, and has established a Joint Project Office (JPO) for the management of project activities at the Naval Undersea Warfare Center (NUWC) Division, Newport, RI.

Shortly after assembly of the Joint Service Team, several critical observations were made:

- The key to interoperability is not connectivity alone, but rather understanding communications content. This is best promoted by defining an open, object-oriented software architecture that could be used by both legacy and newly built systems.

- The process used to plan, schedule, and otherwise coordinate a multiple-facility, multiple-service exercise must be integral to the development of the architecture, or the capabilities it offers might never be fully utilized.

- The architecture must be conducive to refinement over time and coexists with facility-unique applications. This requires a disciplined architecture development/refinement process. The team adapted the Defense Information Systems Agency (DISA) domain-engineering approach to help develop the architecture and recommends the Product-Line Approach for implementation and life cycle maintenance.

- Significant investments are being made in other closely related areas such as, Defense Modeling and Simulation Office (DMSO), High Level Architecture (HLA) and the Joint Simulation System (JSIMS) program. TENA must leverage as many of these efforts as practical.

- The TENA concept is radically new to our community. Planning for transition is key to its ultimate acceptance.

STATUS

The project team tested its architecture development process in FY96 producing a "Pilot Architecture." This work was reviewed in several public forums. These reviews were highly supportive of TENA's effort. Two consistent suggestions were that TENA should focus first "on breadth, not depth", and that there should be more emphasis on "problem-space vs. solution-space". These considerations and additional engineering effort has resulted in this refined "Baseline Architecture."

The TENA Baseline contains sufficient detail to continue further analysis and risk reduction efforts and is a good vehicle for discussion, experimentation, and refinement. It is not yet appropriate to use these documents as the blueprint for a major system development. After community feedback, results from risk-reduction prototypes, experiments, and other ongoing efforts are synthesized, the cognizant TENA Baseline documents will be updated as "TENA Rev 0." TENA Rev. 0 will be the appropriate source of design information for a TENA-compliant system implementation.

New paradigms have emerged since the end of the Cold War for military systems acquisition and utilization. These new paradigms include reduced acquisition costs and joint-Service interoperability. These changes have caused the Test and training communities to be faced with a combination of reduced funding and the requirement to test and field new, more advanced and interoperable weapons systems. Under current and future budget constraints, the T&E and training communities will need advanced, more cost-effective technologies in order to provide the necessary capabilities for these upcoming systems. The purpose of the TENA project is to provide these advanced capabilities through the establishment of an architecture that efficiently and effectively fosters the sharing, reuse, and interoperability of test and training resources.

TENA will enable the necessary trends toward integration of test and training capabilities. Additional benefits include: reduced cost to integrate new instrumentation to a common architecture vs. customizing instrumentation for each range, and cost savings associated with reusing major software components across multiple test and/or training facilities. However, the architecture is only part of the essential revolution in test and training. New business methods and practices are also required.

The problem for TENA and the transition effort is to determine the best methods for implementing a transition to a new way of doing business, while at the same time maintaining significant latent capability in our range infrastructure in a reduced cost environment. Transition planning must accommodate a shift in methodology for range systems hardware and software development, while at the same time, support the business process and management modernization efforts now underway in the test and training communities. The TENA project is introducing several new concepts. These include:

- Product-Line Approach,

- Logical Range Concept,

- Logical Range Business Process Model, and

- Object-Oriented Architecture

This section includes an overview of the transition planning responsibilities of the major participants in the TENA project. These include the Sponsoring Program Office, the Developer, the Lead Service/Agency Installation, and the User Community.

SPONSOR—CENTRAL TEST AND EVALUATION INVESTMENT PROGRAM OFFICE

PROGRAM MANAGEMENT

The CTEIP office has the responsibility for approving any transition plans, recommendations, or procedures that may be submitted by the TENA Project Office.

FUNDING

The CTEIP Program Office is responsible for approving a funding plan to support the transition of TENA to a lead service or agency.

TRANSITION SUSTAINABILITY

Under the Product-Line Approach [TENA, 2], there is an organization responsible for developing the planning and guidelines for transition sustainability. An architecture is a living entity and, as such, cannot be abandoned once promulgated. The Sponsor is responsible for ensuring that the TENA architecture is sustained until a point that the community adopts it or until a point where enough sites are TENA compliant to sustain the architecture through combined inertia. One approach for supporting programmatic and budgetary transition for a project such as TENA is sponsorship by the Principal Deputy Under Secretary of Defense (Acquisition and Technology (PDUSD)(A&T)). That is the approach used for the Joint Test and Training Range Roadmap (JTTRR). TENA and JTTRR are linked in the sense that JTTRR is intended to provide for a corporate management methodology for sustainment and investment for test and training ranges, facilities, and other resources.

JOINT TEST AND TRAINING RANGE ROADMAP

The Joint Test and Training Range Roadmap (JTTRR) is being developed in response to direction from the PDUSD (A&T). Test and training community input and review are provided by three committees chartered under the Defense Test and Training Steering Group (DTTSG): CROSSBOW, the Test and Evaluation Resources Committee (TERC), and the Training Instrumentation Resource Investment Committee (TIRIC).

The intent of this roadmap is to engender a corporate attitude and approach toward test &

training capability sustainment and investment. When consistently acted upon, it will advance the goal of enabling our warriors and weapons to *Dominate the Battlefield*. To that end, it champions the infusion of technology innovation. It also proclaims a common foundation of core system requirements that foster appropriate, efficient, and effective sharing, reuse, and interoperability among our test and training communities.

The term "range" as used herein includes not only open air ranges but also facilities and organizations that support test and training through M&S, stimulation, threat replication, target presentation, and information systems support. The roadmap follows from the strategic planning guidance provided in: *Joint Vision 2010*, the T&E Strategic Plan, Defense Technical Area Plans and Service training and planning documents.

JTTRR is guidance for in the DoD test and training communities who are responsible for range requirements definition, program execution, systems development, operation, and life cycle support. [JTTRR, 1997] It is acknowledged that the Services and communities within each Service have wholly unique and special needs that may not benefit from a common corporate sustainment and investment approach. There is no intent to suggest that this roadmap is prescriptive for those situations.

Another common methodology that will also support TENA transition planning is the Simulation, Test, and Evaluation Process (STEP). For the test and evaluation community, the ultimate user of TENA is the acquisition manager, and STEP is designed to involve "testers" early in the engineering process.

SIMULATION, TEST, AND EVALUATION PROCESS

The Simulation, Test, and Evaluation Process (STEP) [STEP, 1996] is an iterative process that integrates both simulation and test for the purpose of evaluating the performance, military worth, or effectiveness of systems to be acquired. In STEP, simulation and test are integrated, each pending on the other to be effective and efficient. Simulations provide predictions of the system's performance and effectiveness, while tests are "part of a strategy to provide information regarding risk and risk mitigation, to provide empirical data to validate models and simulations, to permit an assessment of the attainment of technical performance specification and system maturity, and to determine whether systems are operationally effective, suitable, and survivable for intended use." [DOD 5000.2R] A byproduct of this process is a set of models and simulations with a known degree of credibility providing the potential for reuse in other efforts.

STEP is driven by mission need and system requirements. The product of STEP is information. The information supports acquisition program decisions regarding technical risk, performance, system maturity, operational effectiveness, suitability, and survivability. As such, STEP is a sub-process of the overall acquisition process. STEP applies to all acquisition programs, especially Major Defense Acquisition Programs (MDAP) and Major Automated Information Systems (MAIS).

DEVELOPER—TENA PROJECT TEAM

The TENA architecture is being developed by a tri-Service integrated project team that is directed by Mr. Edward Dunn of the Naval Undersea Warfare Center, Division Newport. Mr.

Dunn responds to Mr. Richard Pace of the office of Director, Test, Systems, Engineering and Evaluation, Resources and Ranges for technical and funding oversight for TENA and other CTEIP projects.

DOCUMENTATION

The Transition Plan will be the guiding document for the transition of TENA. It will provide guidance, schedule, cost and technical details to support implementation of the TENA architecture at a specific site. The Transition Plan is supplemented by other documents in the TENA Baseline Project Report. These include:

- Management Overview,

- Technical Reference Architecture,

- Product-Line Approach—A Cooperative Methodology for Supporting Test and Training Resources and Ranges,

- Logical Range Business Process Model,

- TENA Application Concepts, and

- Integrated Validation and Verification Plan.

AWARENESS AND FEEDBACK

During FY98 the TENA Project Team will be conducting awareness briefings at various public forums, test and training organization meetings, and specific briefings, as required, to familiarize the stakeholders with various aspects of the project. These briefings will be used to generate feedback that will be used by the Project Team to refine the architecture, the Business Process, Application Concepts, Transition Plan and the Product-Line Approach.

TENA ARCHITECTURE DEVELOPMENT TESTING

The developer will provide results of architecture development testing which includes engineering-level tests of critical features of the architecture during FY98, operational-level testing during FY99, and parallel operations (validation testing) in FY00. Test plans will be developed for each planned test.

TRAINING

The development organization has the responsibility to provide any required training to support the TENA architecture transition.

SCHEDULEE

The Transition Plan will include a schedule to support TENA Architecture testing. A draft schedule follows:

Figure 1. TENA Project Transition Planning

ACCEPTANCE TESTING

Acceptance testing will be in accordance with the Integrated Validation and Verification Plan contained in Volume VII of the Baseline Project Report. A detailed test plan will be provided for the installation testing in FY00.

LEAD SERVICE/FACILITY INSTALLATION

If a lead service or installation is selected by the CTEIP Program Office, that service or agency will have the responsibility of participating with the TENA Project Office to develop a mutual facility/site installation plan. The TENA Project Office will make a recommendation to the CTEIP Program Office by the end of FY98. The recommendation will be based on specific criteria offered in the section titled, Range Transition Candidate Assessment Criteria.

FACILITY SITE PLAN

A facility site plan will be developed by the Lead Service range or Agency facility in conjunction with the program office and the developer.

SCHEDULING

The selected Lead Service/Agency facility will coordinate a schedule with the TENA Architecture Project Office to ensure minimal impact to ongoing test and/or training operations.

RANGE TRANSITION CANDIDATE ASSESSMENT CRITERIA

A procedure for determining which range or facility will become the lead service transition

candidate will require consideration of a series of management, hardware, mission, and cost elements. Some of these elements may be more pressing or demanding than others, and a balanced assessment technique should be used. Transition candidate assessment criteria may include the issues discussed in the following paragraphs.

Management Support

To what level is management accepting of the TENA Architecture concept and transition plan? Is there clear evidence of Business Process Re-engineering thinking on the part of management staff?

Mission Criteria Fit

Does the range have a particular mission or do criteria exist that could be enhanced measurably if TENA is implemented here first? Is a critical DoD acquisition program scheduled for near-term testing on the range?

Staff Preparation

What is the disposition of staff and their level of acceptance to changes in the future way range business will be accomplished? Is the staff customer oriented and aggressive in meeting unique customer requirements?

Cost of Labor

Is a transition to TENA warranted because of potential cost savings, or is the cost of transition worth it? Are there unique labor cost issues that overwhelming mandate a transition?

Infrastructure Readiness

Is the range on the list of sustainable Defense T&E Complex (DTEC)? Is the range facilities and support structure future focused and likely to support a transition decision? What is the average age of computers and range systems?

Legacy Systems Issues

Define any issues dealing with legacy systems that may impact the introduction of TENA at the facility or site. Is the facility concerned about TENA impact to legacy systems?

Unique Test or Training Requirements

Describe any unique test or training requirements, such as the requirement to support upcoming large acquisition program testing.

Software Support Environment

Describe the software development and support environment. Is the facility using object-oriented programming, open systems approaches, software reuse planning?

Computation System Capability

Are the necessary computers installed to support data requirements?

Networks

What is the condition of local area networks? Are gateways available to support data transfer to off-range entities?

Joint Test and Training Environment

Does the facility operate in a joint environment? Are testing and training exercise requirements supported simultaneously?

Improvement and Modernization Forecast

Where does the candidate range stand with regard to Improvement and Modernization (I&M) planning for the future?

USER COMMUNITIY

User community involvement is essential during the development phase of the architecture, as well as, the testing and implementation phases. The TENA Project Team actively solicits comment and review—and will use it. The team has made and will continue to make changes and improvements in response to community inputs.

CTEIP program projects are not normally funded for sustainment after the initial Joint Improvement and Modernization (JIM) program development activity is completed. The intent of the CTEIP Program Office is that the services and/or DoD agencies will implement the capability into existing infrastructure. This concept is clearly understood for hardware in a test instrumentation system.

TENA is an architecture that will require additional attention and upgrade after delivery to be truly effective. TENA is applicable to both the test and training community open air ranges, but it also impacts other non-traditional test and training programs such as modeling and simulation (M&S). TENA cuts across all Services and several federal agencies. Much of TENA is grounded in the technology and architecture advances that are driven by industry telecommunications and computing segments. The different nature of the TENA project is significant enough to represent a requirement for a centralized management methodology designed to support rapid upgrade of software architectures, while at the same time allowing for "bottoms-up" market-driven initiatives to thrive. That methodology is the Product-Line Approach (PLA), which is presented in Volume II of the Baseline Project Report. The TENA Transition process is based upon the PLA.

The TENA Transition approach consists of four phases:

- Conduct Product-Line Approach Analysis,

- Conduct Logical Range Pilot Effort for Concept Exploration,

- Determine Product Line Organization, and

- Establish Product-Line Approach.

PRODUCT-LINE APPROACH ANALYSIS

The PLA Analysis is a six-month project that takes a critical look at how to apply the PLA to test and training ranges and facilities. This phase will evaluate problems and concerns with existing ranges, establish why product lines are important, identify potential reuse opportunities, evaluate the range management organization, and determine critical business and economic factors. The output of this phase will be a product-line practice framework for test and training resources and ranges and a draft PLA organization.

LOGICAL RANGE PILOT EFFORT FOR CONCEPT EXPLORATION

The Logical Range pilot effort will be a concept exploration applying a product-line framework to a selected candidate OAR. The second phase will select some TENA architecture critical features and applications and evaluate problems that might be encountered implementing the PLA. The effort will also concentrate on issues related to developing the system architecture from the Technical Reference Architecture. The end result will be to reduce the risk of implementing a PLA for test and training resources and ranges. An output of the pilot effort will be an evolution strategy and draft product group/product support group management strategies.

IDENTIFY TEST AND TRAINING PRODUCT-LINE ORGANIZATIONS

Using criteria from this transition plan or other criteria that may be developed in the future, recommendations will be determined for product-line organizations to support the TENA architecture. There are four groups within a product-line organization that may be applied to resources and ranges. [TENA, 2] These are:

- Architecture Group produces the TENA product-line architecture definition (Technical Reference Architecture and domain-specific architectures) for all range development organization products. The architecture group also collaborates in building specific applications by recommending the use of product-line assets to the range product development groups based on user requirements and by analyzing needs and tailoring the product-line architecture for production of the application.

- Component Asset Group develops assets within specific areas of range expertise for use in range products. The asset group also defines and evolves product-line architectures with the Architecture Group.

- Product-Line Support Group defines development and execution environments for range products.

- Range Product Development Groups develop and deliver range products for users in the field. They develop a system architecture using the Product-Line architecture, including the technical architecture and components.

Responsibilities of the product-line organizations are found in the Product-Line Approach,

Volume II, and Table 2 of the Baseline Project Report.

ESTABLISH PRODUCT-LINE APPROACH

After successful evaluation of the TENA architecture and completed verification and validation testing, an implementation strategy, which will consist of the establishment of the Product-Line Approach to supporting test and training resources and ranges, will be developed. This strategy will address:

- Business and economic factors,

- Technical factors,

- Process factors,

- Organizational factors,

- Role of Management, and

- Core competencies and skills

This section lists some of the various commands and activities that have a stake in the success of TENA. It is not intended to be a complete listing, as new stakeholders continue to be identified. Those identified to date include DoD-level offices such as the Director, Test, Systems, Engineering and Evaluation (D,T,S,E&E); Director, Operational Test & Evaluation (DOT&E); the CTEIP Program Office; Joint Projects Office Test & Evaluation (JPO (T&E)); and the Common Test and Training Range Architecture (CTTRA) group. The Major Range Test Facility Base (MRTFB) community, including organizations such as the Test and Evaluation Resource Committee (TERC), Training Instrumentation Resource Investment Committee (TIRIC), and the Test and Evaluation Reliance Investment Board (TERIB). The Range Commanders Council (RCC) represents the independent interests of both test and training ranges.

There are other "aligned" commands and entities, such as the Defense Information Systems Agency (DISA), the Defense Modeling and Simulation Office (DMSO), and the training and acquisition communities which have a stake, although not directly, in the transition of TENA to test and training range and facilities. Operational commanders also have an indirect interest in TENA, particularly when one considers the future directions of T&E being accomplished during Joint Task Force (JTF) exercises and other operational training exercises, such as Roving Sands.

The TENA Project Development Team and its sponsoring organization are currently the strongest proponent of the TENA architecture. Project members will dialog with all of the stakeholders to build proponency throughout the community to ensure that concerns and issues are addressed, and that the transition plan is structured to meet user needs. The target architecture will not be "all things to all people", but in an opportunity to maximize the potential for success, as many of the stakeholder concerns and issues as possible will be considered and addressed in future versions of the Transition Plan. More information on stakeholders and how TENA meets needs can be found in Appendix D.

Life cycle supportability issues must be addressed for TENA to survive and become the living architecture for ranges into the next century. Life cycle supportability issues include TENA compliance, TENA expertise, transition, and software deployment and support. Additional life cycle supportability issues, as well as, cultural and technical issues will be defined during the coming months through discussion with the TENA stakeholders. As the Technical Reference Architecture is used to build multiple system architectures, one issue that is both cultural and technical that will be addressed is TENA compliance. Compliance can be applied to both a facility within the TENA Enterprise and individual components or assets.

DETERMINING TENA COMPLIANCE AT THE FACILITY LEVEL

The purpose of developing compliance ratings is to expedite test planning, asset scheduling and performance for Logical Range exercises and to assist in the distribution/promulgation of product line components to participating facilities.

Compliance within this discussion is described in two separate views:

Category 1: *Levels of Interoperability* based on the ability to perform certain functions that are required to operate within the Logical Range.

Category 2: *Levels of implementation maturity* that facilitate or enable the levels of interoperability.

Full compliance with TENA ensures that interoperability, sharing, reuse, and the full scope of functionality is available among participants without re-engineering software and hardware for each new situation. Partial compliance provides planning, scheduling, interoperability, sharing and reuse at progressively higher implementation levels.

Levels of Interoperability

The compliance capabilities presented below are a representative list of the kinds of functions that are significant within the operation of the Logical Range. The terms used within these capabilities are consistent with and defined in the TENA Object Model [TENA, 6] and the Logical Range Business Process Model. [TENA, 3] We define three primary levels of interoperability:

- *The ability to interoperate with mission space resources* – This implies a level of implementation that incorporates data communication standards within the Logical Range as well as applications to provide browsing and presentation, both locally to the facility and globally within the TENA enterprise. This is a significant capability since it enables planning, scheduling, execution and closeout of logical range exercises with sufficient visibility into individual resources to provide for the needs of many prospective users. Specifically, it provides access to environmental, platform, and event data and operations throughout the TENA Enterprise.

- *The ability to interoperate with secondary resources.* —This gives additional visibility of local facility operations to TENA-compliant systems. Remote users could access secondary resources directly, not just the processed results. Users could operate many secondary resources remotely,

subject to local safety procedures and other local policies. For example, an operator at one site could serve as the radar controller at another site (although personnel may still be needed to operate the radar locally). Raw data streams would be available in near-real time to parties with a special interest in this data.

■ *The ability to interoperate with logistics resources.* This level gives visibility into facility-specific resources that support secondary or general-purpose exercise operations. A facility may want to make computer time, secondary storage, or entire control room facility available for external use.

Within each level, there are additional sub-levels of incremental capability. These include browse, subscribe, publish, and schedule functionality. This list will be refined as TENA evolves.

Levels of Implementation Maturity

Non-Compliant – Facilities at this level have not installed any portion of TENA infrastructure, applications, standards or protocols. Any communication with other ranges is done outside of the TENA Logical Range concept. The facility cannot provide any TENA functional capabilities and is shown in Figure 2.

Figure 2. Non-TENA Compliant Example

Compliant - There are three levels of implementation maturity that progressively migrate from simple to total TENA compliance. These are not presented as mandatory stages of migration that must be adhered to, but representative samples of progressive development that are likely to be followed. Mixing and matching of these levels may take place based on site-specific situations.

■ <u>*Level 1*</u> – This is the first level at which progress has been made toward TENA compliance. It basically is an existing legacy system that has installed a bridge (TENA Bridge) between itself and the rest of the TENA Enterprise. This bridge, shown in Figure 3, provides an instance of the TENA infrastructure that is limited to data communication between participants. Other aspects of the complete TENA system such as asset management, planning and scheduling are not available. The TENA mandatory applications are not installed on the range. Some level of TENA standards have been incorporated either within the assets or are contained within the bridge. This level provides some interoperability, but not reuse of assets.

Figure3TENACompliant-Level

The Bridge shown in more detail in Figure 4 is composed of three segments:

- An interface that understands the format and protocol of the asset.
- A translator that transforms the output of the asset into TENA compliant format and contains the Application Program Interface (API) to the TENA infrastructure. This segment would perform the functions that a compliant asset would perform, such as publish the assets data.

- A set of TENA infrastructure services that support data communication (Distribution, Message, and Connection Services)

Figure 4. TENA Bridge

- ■ *Level 2* – The next level is shown in Figure 5. Some existing Legacy assets of a system are "wrapped" with necessary code/procedures to allow them to interoperate with a fully compliant TENA system. Additionally, some new and compliant TENA assets may exist in the system, and some portions of the TENA mandatory applications may have been installed. All "wrapped" and compliant assets are included in the Logical Range Resource Catalog so that they may be scheduled and shared by other Logical Range participants.

Figure 5. TENA Compliant-Level 2

The distinction between an asset that has a wrapper installed and a truly TENA compliant asset is not made in terms of interoperability, but in terms of sharing, reuse and efficiency. An asset that has a wrapper installed is considered interoperable, but may not be reused on some other TENA facility unless the entire wrapper is also used. A TENA compliant asset is "plug and play" on other TENA facilities, and if the asset is comprised of components, then each of the components is individually reusable. A compliant asset also requires less overhead and provides faster and more efficient processing than a wrapped asset.

- ■ *Level 3* – This is the final level in which the range is fully TENA compliant. The full set of infrastructure services as well as all mandatory applications are resident. The range is able to participate in all aspects of the TENA logical range; planning, scheduling, and interoperability including the reuse of software assets and the sharing of exercise assets. Level 3 is shown in Figure 6.

Figure 6. TENA Compliant-Level 3

The two different views (interoperability and implementation) are presented to illustrate that certain enhancements may be installed on the facilities as they migrate toward full TENA compliance. These enhancements do not in themselves determine compliance. The ability to use these enhancements to perform specific TENA functions is the deciding factor in determining levels of interoperability.

For example, the ability to publish and subscribe defines a level of interoperability without caring whether this ability comes from an asset that has a TENA wrapper installed or an enhanced asset that is designed and built to be TENA-compliant, i.e. independent of the level of

implementation maturity.

The level of interoperability and level of implementation maturity together give a complete picture of facility-level TENA compliance.

DETERMINING TENA COMPLIANCE OF INDIVIDUAL ASSETS

Individual assets also can be discussed in terms of maturity and visibility within the TENA enterprise.

Asset Maturity

Asset states vary along a two-dimensional state space. One dimension represents the maturity of the asset as it is developed, refined and tested. The second dimension represents its visibility to the TENA infrastructure through its presence in the Master Asset Catalog. The valid states of asset maturity are:

- *Nonexistent*--This is the starting point, when a need for a new asset has been identified but no steps have yet been taken to develop or purchase the asset.

- *In Procurement*--In this state, an asset is being purchased, discovered or developed, but is not yet available to the ranges.

- *Exists*--In this state, the asset has been delivered to someone within the range system, but is not necessarily ready for the intended application. For example, the asset may be a commercial product that needs to be tailored to the needs of the ranges.

- *Customized*--In this state, any tailoring that is required to support the intended application has been completed.

- *Functionally Validated*--In this state, the asset has successfully undergone functional tests and is known to operate correctly and to provide the desired capability.

- *TENA Compliance Validated*--In this state, the asset has successfully passed all TENA compliance tests.

- *Functionally & TENA Compliant*--In this state, the asset has passed both functional and TENA compliance tests.

Asset Visibility

In addition to the maturity dimension of an asset, there exists a visibility dimension. The valid states of asset visibility are:

- *Uncataloged*--In this state, the asset does not appear in the Master asset catalog. The TENA infrastructure has no visibility into this asset. The asset can not be directly connected into the logical range.

- *Cataloged*--In this state, the asset is logged in the master asset catalog. The TENA core has visibility into the asset. Other users may be able to examine the properties of the asset or schedule use of the asset, depending on the access restrictions.

TENA EXPERTISE

After the TENA architecture is developed, it will require periodic updates as new standards and protocols are developed in both government and industry. Provisions should be made to preserve the TENA architecture core expertise. This preservation may become the essence of the TENA Architecture Group as the TENA project is transitioned from the existing tri-Service IPT to some other form or organization.

The architecture is critical to the success of the Product-Line Approach. Key product line decisions are made during the process of developing or selecting the product line architecture. These include:

- Naming the critical issues in product line development (product line selection and inclusion, handling commonalties and differences, security, interoperability, reliability in product delivery),

- Determining how the product line support interoperability/component integration issues (e.g., the High Level Architecture (HLA)),

- Compliance and levels of compliance,

- Legacy systems,

- New development,

- Determining plans for change/evolution management within the product line,

- Naming key quality factors (for example, performance, security, dependability) that are essential for the product line,

- Determining how the product line will take advantage of COTS/software sharing, and

- Establishing how systems will be built (operational, system, and technical architectures).

TRANSITION ISSUES

The TENA Transition Plan and the Transition Process are based upon adoption of the Product-Line Approach. The successful implementation of a product line systems approach presents challenges and barriers that are significant but surmountable. Those challenges include:

- *Culture* - Using product-line strategies means that organizations and managers have less direct control over their product developments and increased dependency on other organizations to understand their requirements and provide acceptable solutions. Giving up this control and the necessary dollars to support product line technology and application development may be difficult.

- *Strategic planning* - Product line planning is not only a management process that links related systems. The Range Development Organization must consider the long-term needs of users and the ability to build products for those users. They must take an enterprise-wide look at existing and planned products and look several years into the future in planning for product lines. The future-year development plans should focus attention on product lines as the means to satisfy the plan.

- *Need for tradeoffs* - The Product-Line Approach presents a tradeoff for the user between "build me the exact system I want" and "build me a system almost like what I want using the product line, saving on costs and time."

- *Resource ownership* - Who will "own" the product line components? How will they be funded? These issues require transitioning from program-focused acquisition organizations and budgets to

more commercial product organizations and budgets.

- *Recognition and reward* -The current acquisition system focuses recognition and rewards for personnel on delivered systems. Use of product line strategies necessitates a shift to additionally rewarding and advancing personnel for broadening the utility of products and facilitating their use within and across product lines.

- *User interface* - Users will experience close ties to the development organization within the Product Development Groups. They should experience greater responsiveness through improved needs definition, refinement, and early demonstration. However, operational users must adjust to having more than the program managers as their dependency links to successful system upgrades or developments. This should not be difficult since users today are regularly dependent on a variety of sources for successful systems deliveries.

- *Effects of technological change* - The transition to a Product-Line Approach will mean significant changes in our current way of doing business. We must plan for the effects this will have on the individuals who must carry out the transition and also on those who will be operating under the new approach.

Some conclusions about the potential for cost savings may be found in the Management Overview [TENA,7], and in Volume X, Other Supporting Information.

SOFTWARE DEPLOYMENT AND SUPPORT

Ten years ago, most ranges developed their own tracking, range safety, display, and analysis software. As a result, much of the software was specific to the individual range or range subdivision, even when the functionality did not differ significantly between sites. Hardware-dependent data formats characterized the software implementations at each range. Full-time software personnel were stationed on site to support each implementation.

This software development and support system arose for several reasons. Software was added to the range as an adjunct to the hardware that performed the range functions and was not considered separately. Software was cheaper than hardware and, therefore, not considered a cost driver. No connectivity existed between the ranges, so a requirement for a common approach to software was not identified.

These conditions have changed. The cost of software, relative to hardware, has increased dramatically. At the same time, the dependency of software on its hardware platform has been reduced through the introduction of third- and fourth-generation high-level languages and vendor competition.

Centralized software development, conducted at laboratories remote from the range, has become both possible and desirable. One issue that surfaces when software is developed at a site other than the site where it will be used is the method of delivery. There are four basic methods for software deployment and support:

- Customized software delivery,

- Commercial market software delivery,

- Distributed software download, and

- Just-in-time software distribution.

For a discussion of the merits and disadvantages of each method, please see Appendix C. The TENA architecture will support all of these methods.

Transition management and oversight is the responsibility of the TENA Project Director in conjunction with the Sponsor and user community. The TENA Architecture will make a difference to the way business is done in the test and training communities. However, for lasting and significant progress to be achieved the management and oversight of the transition of TENA must be through establishment of the Product-Line Approach. This is fundamental to the ability of DoD to achieve goals and objectives enumerated at the highest levels of the organization. The benefits of PLA can be seen in the paragraphs below.

An example of a Product-Line Approach implementation is cited in the Software Engineering Institute (SEI) case study, *A Case Study in Successful Product Line Development,* about a European defense contractor that adopted the PLA. Variations across the products in this product line included the hardware configuration, the underlying operating system, the devices and sensors used on the ship, the human-computer interface (including the language of presentation), and a host of other requirements differences.

To handle this wide variation, the company concentrated on the commonalities. They designed a common software architecture featuring disciplined use of layering and components designed using information hiding and encapsulation for tailorability. They adopted a standard set of guidelines to minimize traffic on the network. Along the way, they re-organized away from the one-unit-per-product structure of the past. They adopted an ambitious training program for their personnel and empowered the champions of the idea by placing them in positions of authority.

To date, the company has fielded some 55 variants of the basic ship system. They report development time has fallen to under two years (down from around nine), the hardware/software cost ratio flipped from 35:65 to 80:20, verbatim reuse levels are around 80%, and staffing levels are declining. The integration testing for a new 1.5-million line system can be handled reliably by one or two people. Re-hosting the product line to a new computing platform and operating system can be accomplished in three calendar months. Less tangibly, but just as important, confidence in the software is high, both from developers and customers. Performance problems are rare, as are problems resulting from the highly distributed nature of each system; these have been worked out and no longer arise. Cost and schedule are predictable and manageable.

Significant discussion and review will occur over the next few years as the DoD and Services work towards implementation of a methodology to guarantee fully tested and capable cost-effective systems reach the hands of our warfighters. The TENA Project Team will undoubtedly learn much as those discussions happen. The Transition Plan will be updated as significant concerns and issues are discovered.

ACETEF	Air Combat Environment Test & Evaluation Facility
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
AFWTC	Atlantic Fleet Weapons Training Facility
AOR	Area of responsibility
ASC	Air Systems Command
BoOD	Board of Operating Directors
BPR	Business Process Reengineering
C4I	Command, Control, Communications, Computers & Intelligence
CDAPS	Common Display and Analysis Program
CINC	Commander-in-Chief
CJCS	Chairman Joint Chiefs of Staff
CNO	Chief of Naval Operations
COE	Common Operating Environment
CONOPS	Concept of Operations
COTS	Commercial-off-the-Shelf
CTEIP	Central Test and Evaluation Investment Program
CTTRA	Common Test and Training Range Architecture
DII	Defense Information Infrastructure
DISA	Defense Information Systems Agency
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
DTEC	Defense T&E Complex
DTTSG	Defense Test and Training Steering Group
DTSE&E	Director, Test Systems, Engineering and Evaluation
EXCIMS	Executive Council on Modeling and Simulation

HITL	Hardware-in-the-Loop
HLA	High Level Architecture
HWIL	Hardware-in-the-Loop
ISTF	Installed System Test Facility
IT-21	Information Technology--Twenty-First Century
IV&V	Integrated Validation and Verification
JCS	Joint Chiefs of Staff
JIM	Joint Improvement and Modernization
JITC	Joint Interoperability Test Command
JMASS	Joint Modeling and Simulation System
JPO(T&E)	Joint Project Office (Test and Evaluation)
JRRC	Joint Regional Range Complex
JRTC	Joint Readiness Training Center
JSIMS	Joint Simulation System
JTA	Joint Technical Architecture
JTF	Joint Task Force
JTS	Joint Training System
JTTRR	Joint Test and Training Range Roadmap
JWARS	Joint Warfare Simulation
JWFC	Joint Warfighting Center
LFT&E	Live Fire Test and Evaluation
LRBPM	Logical Range Business Process Model
M&SMP	Modeling and Simulation Master Plan
MAIS	Major Automated Information Systems
MDAP	Major Defense Acquisition Programs
MRTFB	Major Range & Test Facility Base
NAS	Naval Air Station

NCA	National Command Authorities
NTC	National Training Center
NUWC	Naval Underwater Warfare Center
OM	Object Model
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
PDUSD(A&T)	Principal Deputy Undersecretary of Defense (Acquisition & Technology
PE	Program Element
PLA	Product-Line Approach
PMRF	Pacific Missile Range Facility
RCC	Range Commanders Council
RDT&E	Research, Development, Test & Evaluation
SAAM	Software Architecture Analysis Method
SEAD	Suppression of enemy air defenses
SEI	Software Engineering Institute
SETI	Synthetic Environment Training Initiative
SISO	Simulation Interoperability Standards Organization
STEP	Simulation, Test and Evaluation Process
SWIL	Software-in-the-Loop
T&E	Test and Evaluation
TEMS	Test & Evaluation Modeling & Simulation
TENA	Test and Training ENabling Architecture
TERC	Test and Evaluation Resource Committee
TERIB	Test and Evaluation Reliance Investment Board
TFR	Test Facility Resources
TIRIC	Training Instrumentation Resource Investment Committee
TIS	Test Investment Strategy

TRMP	Test Resource Master Plan
USD(A&T)	Under Secretary of Defense (Acquisition & Technology)
UTTR	Utah Test and Training Range
VTTR	Virtual Test and Training Range
WSMR	White Sands Missile Range

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DIRECTOR, TEST, SYSTEMS, ENGINEERING, AND EVALUATION

The Director, Test, Systems, Engineering and Evaluation (D,T,S,E&E) is responsible for developing policy and ensuring appropriate implementation of effective test, systems engineering, and evaluation principles in the acquisition process. D,T,S,E&E is charged with providing oversight for the Secretary of Defense for essentially all test and evaluation resources within the Department, including the MRTFB and the development of test resources such as instrumentation, targets, and other threat simulators.

TENA is a key portion of the JTTRR and is designed to support and reinforce the following decisions for CTEIP investments:

- Fund high-priority multi-Service DoD T&E requirements that enhance adequacy and timeliness of test support to DoD acquisition programs.

- Apply state-of-the-art technologies to correct deficiencies in DoD T&E capabilities.

- Achieve consistency, commonality, and interoperability across Services in test instrumentation, targets, and threat simulators.

- Exploit mobile test instrumentation capabilities as an alternative to fixed facilities where economically and technically feasible.

- Maintain a test resource enhancement program (REP) to meet critical near-term operational test shortfalls.

DIRECTOR, OPERATIONAL TEST & EVALUATION

The Director, Operational Test & Evaluation (DOT&E), is the principal staff assistant and senior advisor to the Secretary of Defense on operational test and evaluation (OT&E) and live fire-test and evaluation (LFT&E) in the Department of Defense. DOT&E is responsible for issuing DoD OT&E and LFT&E policy and procedures; reviewing and analyzing the results of OT&E and LFT&E conducted for each major DoD acquisition program; providing independent assessments to SECDEF, the Under Secretary of Defense for Acquisition and Technology (USD(A&T)), and Congress (House and Senate); making budgetary and financial recommendations to the SECDEF regarding OT&E; and oversight to ensure that OT&E and LFT&E for major DoD Acquisition programs is adequate to confirm the operational effectiveness, suitability, vulnerability, and lethality of the defense system in combat use.

The TENA architecture, along with the Product-Line Approach, will ensure that the policy and guidance promulgated by DOT&E is achieved within budgetary constraints and that fielded systems meet combat requirements.

DEFENSE TEST AND TRAINING STEERING GROUP

The Principal Deputy Under Secretary of Defense (Acquisition and Technology) (PDUSD(A&T)), in a 1994 memorandum [PDUSD(A&T),1994], directed the Director, Test, Systems, Engineering and Evaluation (D,T,S,E&E), to establish and chair a steering group to oversee (1) the acquisition and integration of all training and associated test range instrumentation and (2) the development of acquisition policy for embedded weapon system training and testing capabilities. In addition, the PDUSD(A&T) directed the DTTSG to develop a joint roadmap for achieving commonality and interoperability among training and associated test range instrumentation.

The Product-Line Approach [TENA,2], being proposed by TENA can be a successful methodology for enabling the types of decisions required by the DTTSG. It supports the mission and framework to reduce, restructure, and revitalize the defense test and training infrastructure.

CTEIP PROGRAM OFFICE

The Office of Director, Test, and Systems Engineering and Evaluation, Resources and Ranges (D,T,S,E&E/RR) is the CTEIP Program Manager and provides overall project guidance and funding. Program Element (PE) 0604940D supports the TENA project. Mr. Richard R. Pace, CTEIP Program Element Manager, Office of Deputy Director, Resources and Ranges (RR), Department of Defense, is the Executive Agent. The Chief of Naval Operations, Director, Test and Evaluation and Technology Requirements (N913), is the Executive Agent for Navy projects funded from Program Element 0604940D. Execution will be by the TENA Joint Project Office. The Navy, as the Lead Service for the TENA project, will act as the CTEIP Project Resource Manager.

Common Test and Training Range Architecture

During a Test and Evaluation Resource Committee (TERC) meeting, the following problem statement was developed: "Current range implementations have evolved autonomously in the past. The costs of new acquisition and modernization will preclude ranges from economically meeting future test and training requirements. To achieve efficiency in procurement of range instrumentation and to ensure range interoperability, a common range architecture is required. This common range architecture should provide the capability to upgrade test and training ranges at a lower cost by standardizing common range instrumentation systems and interfaces, minimizing unique range instrumentation, and provide for an efficient mode of range internetting to support real-time data collection, processing, and distribution of test and training data. Since the ranges are Service-operated, a joint Service approach must be developed to ensure that each test and training range within the Department of Defense is included in any modernization or upgrade decision."

In response to that statement, the first CTTRA meeting was held in April 1994. During the intervening years, the CTTRA ad hoc meetings proved that the concept of a common range architecture was feasible, but lacked the resources to execute a program. The CTEIP office sponsored the TENA project, which is now viewed as a joint Service effort to implement CTTRA goals.

The sixth CTTRA workshop, held at NAS Fallon in January, 1997, continued progress toward development of a common range architecture by endorsing TENA's vision, specifically the shift to an object-oriented approach [CTTRA, 97]. That decision is fundamental to achieve the required level of interoperability between ranges and other test and training facilities. Other architectures being developed, (e.g., DII-COE, JTA, JSIMS, and TINA) for the DoD and industry use object-oriented design.

MAJOR RANGE AND TEST FACILITY BASE

The Major Range and Test Facility Base (MRTFB) is comprised of 21 testing ranges around the United States, the Bahamas Islands, Puerto Rico, and the Kwajalein Islands. It consists of a broad base of test and evaluation activities managed and operated under uniform guidelines to provide test and evaluation support to the Department of Defense (DoD) and its components responsible for developing or operating materiel and weapon systems. The MRTFB is a "national asset which is operated and maintained primarily for the Department of Defense test and evaluation support missions, but also to be made available for all users having a valid requirement for its capabilities". [DODD 3200.11]

The MRTFB community expectations and concerns about legacy systems, reinvestment, *Vision 21*, rightsizing, etc., must continue to be solicited and addressed. TENA is the key CTEIP project designed to support the new test and training infrastructure of the year 2000 and beyond. A Common Range Architecture is expected, but cannot be force-fed. It must be the best value solution available to this primary constituency.

T&E Resource Committee

The T&E Resource Committee (TERC) is co-chaired by the Deputy D,T,S,E&E/RR and the Deputy DOT&E. Members of the TERC include representatives from the Services' T&E headquarters and other DoD agencies.

The TERC's function is to ensure the efficient acquisition of common and interoperable range instrumentation systems. The TERC oversees and guides the development of DoD-wide instrumentation requirements and policies for DoD MRTFBs. It manages OSD's Central Test and Evaluation Investment Program (CTEIP).

The TERC aids in overseeing development of infrastructure requirements from a T&E community perspective, ensuring developmental and emergent operational test and evaluation community readiness.

Training Instrumentation Resource Investment Committee

The Training Instrumentation Resource Investment Committee (TIRIC) facilitates working-level activities necessary to support the training range instrumentation and infrastructure responsibilities of the DTTSG. The TIRIC provides oversight of Service training range instrumentation programs (non-threat related) to preclude inadvertent or unnecessary duplication of capabilities. The TIRIC is chartered to identify the potential for cooperative efforts, both among the Services for training applications, and between the training and test communities through interaction with the TERC. The TIRIC is chaired by the Director for Readiness and Training Policies and Programs, office of the Deputy Under Secretary of Defense (Readiness).

The overarching mission of the TIRIC is to ensure the efficient acquisition of common and interoperable range instrumentation systems. The TIRIC's primary initial focus is twofold: first, to oversee and guide the development of instrumentation requirements and policies for DoD training ranges; and second, to foster common development and to improve the interoperability of instrumentation systems used by the training and T&E communities.

A secondary mission of the TIRIC is to support the DTTSG in analyzing infrastructure requirements from the perspective of the training range community, and assisting in the development of the overall infrastructure objectives established in the "joint roadmap" (or Joint Training and Test Range Roadmap (JTTRR)).

The Product-Line Approach [TENA,2], being proposed by TENA can be a method for enabling the types of decisions required by the TIRIC. It supports both the primary and secondary mission of the TIRIC and provides a framework to reduce, restructure, and revitalize the defense test and training infrastructure.

Test and Evaluation Reliance Investment Board

The Test and Evaluation Reliance Investment Board (TERIB) consists of 12 senior technical T&E experts from the Service ranges appointed by the BoOD. Representatives from the Defense Agencies and the CTEIP Program Element manager serve as advisors to the TERIB. The TERIB coordinates the T&E Reliance process for investment planning and execution; finalizes the recommended Service Test Resource Master Plan (TRMP) produced by the JPO(T&E); develops a recommended Service Test Investment Strategy (TIS) and long-range vision for T&E; reviews investment requirements, recommends priorities, identifies joint investment opportunities, and fosters combining Service needs and solutions into joint Service and CTEIP-funded investment projects; and coordinates and conducts special studies as assigned by the BoOD.

The TERIB first endorsed the concept for TENA in late 1995 and during FY97 endorsed

continuation of the project and indicated concurrence with long range plans for the TENA architecture.

JPO (T&E)

The JPO coordinates the execution of Service and multi-Service T&E investment projects in support of the BoOD. Specific principal responsibilities of the JPO(T&E) include:

- Deconflicting and integrating the various T&E investment products (Services submissions, CTEIP submissions, Test Resources Master Plan (TRMP) and Test Investment Strategy (TIS) production) and development of T&E investment requirements prioritization,

- Using Business Process Reengineering (BPR) methodologies to develop and recommend actions to the BoOD for process improvements to enhance the management of T&E investments,

- Assisting in the coordination of the annual OSD Test Capability, Budget and Investment Review process,

- Managing the T&E Corporate Information Management (CIM) initiative, and

- Conducting special studies as directed, to include new projects requirements development, on going project reviews, and developing opportunities for common maintenance facilities.

RANGE COMMANDERS COUNCIL

The Range Commanders Council (RCC) represents the T&E and training ranges, and is responsible for achieving commonality and standardization in range technical capabilities. The RCC assists the BoOD in identifying T&E range investment and sustainment requirements and providing personnel with the expertise required to address complex technical questions regarding T&E ranges. The scope of activity of the RCC is to resolve common problems; discuss common range matters in an organized forum; exchange information and thereby minimize duplication; conduct joint investigations pertaining to research, design, development, procurements, testing and interoperability; coordinate major or special procurement actions; develop operational procedures and standards for present and future range use; and encourage the interchange of excess technical systems and equipment.

The TENA Project has maintained communications with several RCC subgroups and the RCC Executive Council. The TENA Air Force Deputy is a member of the Telecommunications and Timing subgroup and has acted to gather RCC concerns and issues. He has served as the primary liaison with the RCC for the TENA Project Team. The RCC is a major user of the TENA architecture and will have a major contribution to developing a transition methodology for TENA at open-air ranges.

TEST RANGES AND FACILITIES

Test directors will be doing business in completely different ways in the future. Many more tests will take place in a joint environment and on "other Service" ranges. The TENA architecture will offer significant new capabilities for test directors to support functions such as test planning, scheduling, exercise execution, data acquisition, and data product development and delivery.

TENA has developed a Business Process [TENA,3] for the Logical Range which will offer new options for the test ranges and facilities, such as those facilities listed below.

Open Air Test Ranges

Test ranges, by policy, each have unique capabilities at different environmentally suited locations to support specific types of test and evaluation activities. [JTTRR,1997] Major MRTFB T&E support capabilities are based on a combination of user requirements and the mission of the activity, and the avoidance of unwarranted duplication within the Department of Defense. Range characteristics required to support open-air test events depend on the objectives and complexity of the test.

Hardware-In-The-Loop Facilities

Hardware-in-the-Loop (HITL) is a hybrid simulation that includes actual system (prototype or production) hardware or software in conjunction with digital models and external stimuli to demonstrate the operations and functions of the hardware/software within an environment simulating actual operating conditions. Functioning of the simulation with the hardware or software is often accomplished in an integration laboratory.

HITLs can be used to demonstrate new technology; evaluate designs, concepts, and prototypes; and show the integration of hardware and software. It allows early evaluation without the expenditure of live test resources, facilitates live test development by identifying desired test conditions, and can be used for development of data collection plans. The lab environment may provide for easier data collection as a result of better access to components.

Installed Systems Test Facilities

Installed System Test Facilities (ISTF) are facilities where entire systems or sub-systems get their first workout in the environment in which they will operate (e.g., inside an aircraft). A full-capability ISTF has the ability to mix a complete spectrum of players from synthetic (digital models) to real (actual hardware) to hybrid (a combination of both); the ability to provide multi-level threat simulations (open-loop and closed-loop signal simulators, including actual or simulated threat system hardware); and the ability to provide simulations of all C3 elements a system would be expected to operate in the real world. The Navy's Air Combat Environment Test and Evaluation Facility (ACETEF) at Patuxent River, MD, is an example of an ISTF.

Integration Laboratories

An Integration Laboratory (IL) is a facility that supports the integration of system components and/or software in a laboratory environment for development, experiments, and testing. The integration laboratory "simulates" (or replicates) a system to a known extent and allows the modification/addition of component hardware/software for use without many of the restrictions or difficulties that would be encountered using actual system hardware or host platforms. Testers will obtain the benefits of HWIL/SWIL testing. The IL is comprised of the physical support structure and components that make HWIL/SWIL testing and evaluation possible.

Measurement Facilities

Measurement facilities (MFs) are used to quantify or measure parameters (such as thrust, radar cross section, and drag) of a test article in precise terms. Examples of such facilities are wind tunnels, radar cross section facilities, antennae pattern ranges, and engine thrust stands.

TRAINING COMMUNITY

T&E and training occur on both test and training ranges. The need exists to electronically link test and training facility resources for greater efficiency and cost effectiveness. Modest joint training requirements do exist for electronically linking single ranges complexes to constructive/virtual simulations. [JCS, 1994] Associated with this need is the opportunity to form an electronic, on-line, user-friendly, resource-library information database. The TENA architecture will address both Service and joint training requirements. [TENA,4] The TENA Project intends to establish more direct liaison with the training community during FY98. Training members have attended conferences where TENA was presented, as well as the FY96 TENA Baseline Review held in Newport in October/November 1997. The office of the Deputy Under Secretary of Defense (Readiness)/TIRIC is expected to sponsor a symposium during FY98 that will focus on specific training community issues related to TENA. Several of the draft scenarios for TENA verification and validation contain training objectives. [TENA,5] Some example potential stakeholders for the training community include JWFC and various training ranges.

Joint Warfighting Center

The Joint Warfighting Center (JWFC) is a Chairman Joint Chiefs of Staff (CJCS) organization designed to support all CINCs' training and exercise programs throughout the Joint Training System (JTS). The JWFC also supports joint doctrine development, both for current needs and future concepts for joint organizations. The JWFC is an on-line organization experienced in exercise support, doctrine development, joint training functions, and concept development capabilities. The fundamental goals of joint doctrine and joint training policy include unity of effort and joint readiness. The JWFC exists to maximize achievement of these goals throughout the joint community while continuing to facilitate joint doctrine development, provide joint training and exercise support and expand joint management services.

It is expected that as TENA continues to develop the architecture that the JWFC will have input on issues dealing with joint training.

Training Ranges

Training ranges often have redundant capabilities at geographically separated locations. This is necessary to support regular use by forces at dispersed locations established by homeporting/homebasing strategy. To meet the repetitive requirements of basic-level training, basic training facilities must be located in proximity to a user's base. Since in many cases the units making use of these ranges are conducting similar training (e.g., air combat maneuvering for fighter and strike-fighter units based throughout the country), the Services must maintain multiple training ranges with "redundant" capabilities. Our national defense strategy of force projection vice forward-deployed forces has enabled the use of test and training ranges to provide new scenarios and combat realism. Some training ranges which provide graduate-level training often have different capabilities at a few major locations (e.g. Atlantic Fleet Weapons

Training Facility (AFWTF), National Training Center (NTC), Ft. Erwin). The relatively larger operating space volume and the cost of more sophisticated threats and instrumentation required to support advanced-level training generally preclude ranges designed to support those levels in the immediate vicinity of each homeport/homebase.

There is duplication in test and training range capabilities, and in many cases both test and training activities occur on the same range. Historically, separation of test and training ranges was more an issue of accuracy of tracking or test instrumentation or telemetry requirements. However, technology now allows for development of some economies of scale in combining test and training in the same battlespace, even at the same time. TENA will provide an architecture designed to support test and training in a "mutual sense."

ACQUISITION MANAGERS

Service acquisition managers are under intense pressure to reduce acquisition budgets and to deliver high-quality weapons and platform capabilities. More effort is being concentrated on M&S and other aspects of acquisition reform. Previously, most acquisition managers expected the MRTFB community to have the capability and capacity to provide whatever test need existed. If the capability or capacity was not present, the acquisition managers had enough money to purchase the T&E capability for his own program. Declining budgets have changed this approach. Reuse, sharing, and interoperability are the wave of the future. Acquisition manager concerns about the availability of test capability/capacity in a new rightsized Defense T&E Complex (DTEC) must be addressed by TENA.

Honorable Paul G. Kaminski, the Under Secretary of Defense for Acquisition and Technology, made the following observations about reducing acquisition cycle time requiring a cultural change composed of the following elements:

- An integrated simulation, test and evaluation process that provides *Continuous Insight* -- to ensure that quality is built into programs from the start,

- An emphasis on *Prevention over Cures* -- where simulation, test, and evaluation is used to identify and resolve problems early; and

- A focus on overall *Program Success, not suboptimum Functional Area Performance*; an elegant test program is meaningless if we fail to get superior capability into the hands of the warfighter. [Kaminski, 1995]

TENA proposes that the Product-Line Approach [TENA,2], along with the TENA architecture will support Mr. Kaminski's conclusions and provide the necessary "cultural change" and the "*continuous insight"* to the acquisition, test, and training communities.

OPERATIONAL COMMANDERS

Definite trends in operational testing and, in some cases, limited developmental testing, show that T&E will occur in a training environment in the future. This may happen in a "not-to-interfere" basis during the conduct of Joint Task Force (JTF) exercises or in a "piggy-back" fashion after the training has been conducted, but before the operational assets, people and equipment, have been removed from the field.

Operational commanders have begun to participate earlier in the acquisition cycle to refine and define required operational capability. Increasingly M&S is being used to help ensure that the eventual delivered system has the essential capability to perform warfighting tasks. The TENA architecture must support the operational commander in those test and training events that are conducted in an operational environment.

Many DoD test and training ranges and facilities have a wide range of customers, serving all Services and both the test and training communities. "Joint" has come to identify ranges that support more than one service, and whenever both test and training are conducted at a single range, the term "mutual" is used to describe this activity. Joint/mutual use of ranges in single and multiple operations has substantial historical precedent.

MODELING AND SIMULATION

The Modeling and Simulation Master Plan [M&SMP, 1996] and its companion Navy Test and Evaluation M&S (TEMS) Master Plan [NAVY TEMS, 1997] establishes a framework for incorporating modeling and simulation as an integral part of the test and evaluation process. The Honorable Paul Kaminski noted that modeling and simulation will:

- Help create developmental and operational test scenarios and improve the planning process,

- Allow dry runs of planned tests in "synthetic environments" to verify that test conditions can be evaluated cost-effectively and with sufficient realism,

- Be used to help plan the test program and select test objectives in a way that reduces the need for expensive field test assets, many test iterations, and long duration tests,

- Facilitate evaluation of system performance characteristics otherwise not possible because of limited test resources, environmental restrictions, and safety constraints; and

- Permit operational testers to use virtual prototypes to perform early operational assessments. [Kaminski,1995]

The underlying approach will be to model first, simulate, then test, and then iterate the test results back into the model. Just as we speak now of "test, fix, test". . ., we should now plan our development programs so that they "model, test, model." The intent is to ensure that modeling and simulation becomes a truly integral part of our test and evaluation planning. We must consider all the tools and sources of information available to us in developing and evaluating the performance of our weapon systems.

The TENA architecture will be the bridge to M&S through the DMSO High Level Architecture (HLA). This will ultimately enable connectivity in a "plug and play" fashion between the M&S environment and live open-air ranges and test facilities.

Defense Modeling and Simulation Office

On June 21, 1991 the Undersecretary of Defense for Acquisition, Mr. Don Yockey, established the Defense Modeling and Simulation Office (DMSO) to serve as the executive secretariat for the Executive Council on Modeling and Simulation (EXCIMS) and to provide a full-time focal point for information concerning DoD modeling and simulation (M&S) activities. Currently the DMSO promulgates M&S policy, initiatives, and guidance to promote cooperation among DoD

components in order to maximize efficiency and effectiveness. DMSO is a staff activity reporting to the Director, Defense Research and Engineering, office of the Undersecretary of Defense for Acquisition and Technology (USD(A&T)).

The DMSO's functions include, but are not limited to:

- Promulgating policies, at the direction of the USD(A&T), that facilitate the application of M&S among joint education and training, research and development, test and evaluation, and operations and cost analysis disciplines.

- Distributing USD(A&T)-approved guidelines to assist in military Service component development of consistent M&S plans in the areas of: configuration management, verification, validation, accreditation, and releasability.

- Developing USD(A&T)-approved liaison processes to coordinate and assist in the development, acquisition, and sharing of M&S technology, standards, verification, validation, and accreditation processes among DoD Components and the Defense industry.

- Developing USD(A&T)-approved mechanism to foster cooperation among DoD components to maximize M&S interoperability while eliminating redundant development of advanced M&S technologies.

- Advising USD(A&T) on matters relating to improving the use of models and simulations that support input to the Joint Requirements Oversight Council, Defense Planning and Resource Board, and the Defense Acquisition Board.

- Initiating and sustaining a research and development program aimed at improving M&S tools, data bases, associated network concepts, standards, interoperability, interfaces, and accreditation technologies applicable to the operations analysis, RDT&E, and training elements of Defense business.

- Documenting requirements for, and developing programs to establish, a clearinghouse network to facilitate M&S information exchange among appropriate users.

- Determining requirements, delineating procedures, and identifying research and development efforts to improve effectiveness and efficiency among existing systems and facilities where appropriate.

- Identifying high-priority M&S technology objectives for future investment.

- Documenting resources required and available to execute candidate M&S improvement projects and providing the EXCIMS a basis to approve joint investment plans for M&S projects.

- Conducting evaluations of funded M&S projects to verify progress and validate candidacy for continued resourcing or termination as appropriate.

Three major programs involving the use of M&S that are of interest to the TENA Project Office are discussed in the following paragraphs.

JOINT SIMULATION SYSTEM

The Joint Simulation System (JSIMS) is the flagship DoD modeling and simulation program to provide next generation training, mission-planning, and mission-rehearsal capability for warfighting CINCs and the Services with better functionality and lower operating costs than

today's systems. An Orlando-based Joint Program Office has been established by agreement between the Director of Defense Research & Engineering, all four service Operations Deputies, and the Director of the Joint Staff. JSIMS is a cooperative development effort among Services and department agencies that will yield a whole far greater than the simple sum of its parts. Policy oversight is by J-7 and DUSD (Readiness).

JSIMS is a simulation system that supports the twenty-first-century warfighters preparation for real-world contingencies. The system provides garrison and deployed exercise capability to meet current and emerging training and operational requirements in a timely and efficient manner. By interfacing to the warfighters real go-to-war systems, the view into the simulation world mirrors that of the real world. JSIMS is a single, distributed, seamlessly integrated simulation environment. It includes a core infrastructure and mission space objects, both maintained in a common repository. These can be composed to create a simulation capability to support joint or Service training, rehearsal, or education objectives.

JOINT MODELING AND SIMULATION SYSTEM

The Air Force (Air Systems Command (ASC) and Wright Laboratory) has been developing a common modeling and simulation (M&S) architecture for more than 10 years. For the last 4 years, under the Joint Modeling and Simulation System (J-MASS), the emphasis has been on simulation architecture and simulation objects (i.e., models or applications). The major thrusts of J-MASS have been:

- Development of a common digital simulation architecture,

- Definition of standard interfaces,

- Application of commercial standards (e.g., POSIX, MOTIF, X-Windows, CORBA),

- Use of the visual Computer Assisted Support Environment (CASE) tool environment, and

- Application of modeling and simulation to the acquisition life cycle.

J-MASS has used incremental software releases as part of a prototype development process to refine user requirements and elicit feedback from the acquisition M&S community. The current version (J-MASS Release 2.0) is being used in several modeling and analysis domains (Electronic Warfare R&D, Test and Evaluation, and Intelligence).

JOINT WARFARE SIMULATION

The Joint Warfare Simulation (JWARS) will be a state-of-the-art, closed-form, constructive simulation of multi-sided, joint warfare for analysis. Users of JWARS will include the Combatant Commanders, Joint Staff, Services, Office of the Secretary of Defense (OSD), and other DoD organizations. Applications will include the following:

- Evaluation of courses of action,

- Analysis of force sufficiency,

- Assessment of force structure alternatives,

- Joint Warfare Capability Assessment, in particular, development of joint-capability issues and assessment of trade-offs,

- Determination of requirements for new war fighting capabilities,

- Analysis of weapon system alternatives, in particular, cost and operational effectiveness analysis, and

- Analysis of alternatives for program and budget reviews.

SIMULATION INTEROPERABILITY STANDARDS ORGANIZATION

The Simulation Interoperability Standards Organization (SISO) vision is to be the international organization responsive to the diverse needs of the developers, procurers, and users of modeling and simulation technologies promoting interoperability and reusability.

Interoperability is defined as the ability of a model or simulation to provide services to and accept services from other models and simulations, and to use the services so exchanged to enable them to operate effectively together. SISO's vision of interoperability is not restricted by data transfer time constraints, the number of interacting models and simulations, or the distances between the interacting models and simulations. Technologies supporting SISO's M&S interoperability include communication mediums and communication architectures.

Reusability is defined as the ability of models, simulations, and the above interoperability technologies to have design characteristics enabling their use for multiple applications with little or no modifications. Technologies supporting reusability include fidelity indices, archive retrieval, and object- oriented software design,

Standardized data interchange formats, configuration management, and verification/ validation are additional technologies applicable to both interoperability and reusability.

These emerging M&S interoperability and reusability technologies are the foundation for real-time, complex, distributed and interactive modeling and simulation integration enabled by the SISO vision.

Defense Information Systems Agency

Another "aligned" command of interest to the TENA Project Team is the Defense Information Systems Agency (DISA). DISA is the DoD Agency responsible for information technology, and is the central manager of a major portion of the Defense Information Infrastructure (DII). DISA is responsible for planning, developing, and supporting Command, Control, Communications, Computers and Intelligence (C4I) that serve the National Command Authorities (NCA) under all conditions of peace and war. DISA is subject to the direction, authority, guidance, and control of Assistant SECDEF ((ASD) (C4I)) and reports to the Chairman of the Joint Chiefs of Staff for operational matters.

JOINT INTEROPERABILITY TEST COMMAND

The Joint Interoperability Test Command (JITC) is the DoD's facility for evaluating the interoperability of information, communication, and intelligence systems. It also conducts a wide range of developmental, operational, and standards conformance tests for private industry, the Joint Staff, U.S. and allied military Services, Commanders-in-Chief (CINCs), and several federal agencies.

The Joint Interoperability Test Command is a subordinate command of the Defense Information Systems Agency (DISA). It is located at Ft. Huachuca, Arizona. JITC has several testbeds and networks to support laboratory, system integration, tactical and strategic level testing of hardware, software, and elements.